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A Local Control Element to Reduce Automation Costs of Injection Wells

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ABSTRACT

The cost-saving potential of a local control element, the automatic flow controller, is established by examining typical automated injection systems. This local control element accurately and automatically regulates the set injection rate. A new rate may be "dialed" easily without systems downtime or extra parts. The reliability of this kind of device reduces the need for constant remote supervisory control and many metering functions. The local control element promotes design simplicity and reduces the need for instrument level training for operating personnel.

INTRODUCTION

The reservoir engineer's recommendation for the most efficient flooding of the zone determines the choice of the systems design for automatically controlling a waterflood injection. The primary method of varying the progress of a flood front is to adjust the injection rate and control this rate accurately. A reliable method providing this capability then becomes the primary concern in automating the injection well.

Equipment costs must be evaluated in designing any automation system. In today's market, the engineer may literally "buy as much automation as he has money to spend." The equipment is evaluated by the amount of automation necessary and its required degress of sophistication.

Basic Systems

Generally, there are three basic systems designs used in automating an injection well. Actual systems may incorporate specific features of all three designs, but the basic distinctions still remain. Fig. 1 represents diagrams of the three basic systems. In these systems, point X is a centralized location, often geographically established, containing data processing functions. Point Y represents field operations at the injection pattern location.

In general, the systems have certain unique characteristics. System A has maximum operational flexibility from the data processing center, utilizes relatively complex instrumentation, and requires maximum capital investment. System B has direct telemetered data input to the data processing center, has centralized monitoring functions, and has a local control element that automatically regulates injection rate. System C incorporates maximum design simplicity and economy, has the lowest basic equipment cost, and has manual input to the data processing center.

Systems B and C are becoming more and more attractive because of their estimated lower cost. This cost difference depends on the substitution of a local control element for the supervisory automatic control capability. The local control element of System B replaces 50 percent of the basic diagram of System A.

In actuality, the local control device is substituted for an electro-mechanical or electro-pneumatic control valve. A savings is established by a direct reduction in valve costs and a reduction in the requirement for telemetering equipment, receiver controllers, and other accessories; thus, investment and operational costs decrease.

The investment dollar savings of Systems B and C revert to a rather simple evaluation. The operations justification of Systems B or C over System A calls for considerable thought and examination. The supervisory automatic control function generally is justified because of the

Illustrations at end of paper.

need to change periodically the injection rate to the flooding zone. The capability of performing this function from centralized Point X is an attractive feature. Two fundamental questions should be asked. [1] How often does the injection rate require resetting in the life of a typical injection pattern? and [2] what is an acceptable time-delay factor in making this rate change? The dollar value of instantaneous remote reset of the injection rate can be established only by an operating company. This systems feature may be more costly than is justified.

THE AUTOMATIC FLOW CONTROLLER

The economic saving potential of the local control element dictates investigation of this kind of device for any automated injection system. The most applicable local element for injection well service is the self-contained automatic flow controller. This device was only recently designed for waterflood applications.

Approximately four years ago, the following problems were expressed to manufacturers of automatic controls:

1. Most injection well flow rates were controlled by adjustable hand chokes set by a downstream rotary meter reading. Meter maintenance caused an ever-increasing expense.
2. Due to pressure fluctuations, the hand chokes required almost a regular readjustment to provide a constant flow rate.

Inasmuch as the choke and meter acted as a flow control mechanism, specifications were written to devise a self-contained local control element to automatically regulate the injection rate.

Criteria

The design criteria follow.

1. The flow rate should be accurately controlled, and performance should not be affected by pressure fluctuations.
2. Both the hand choke and rotary meter are to be replaced by the automatic flow controller.
3. The device should be competitive in price with the rotary meter to realize a savings in hand choke cost.
4. The controller should be rugged in design with hardened quick change trim as common to high pressure control valves for long service life.
5. The device should have a manual, blind flow-rate adjustment mechanism with a reasonable turn-down ratio to easily "dial in" a desired injection rate.

After prototype field tests of approximately one year, a flow controller meeting these specifications [Fig. 2] was made available to the operating producing company.

Mechanics

The flow controller is actually two valves in one. A meter valve is adjusted to the desired flow rate and functions as a fixed orifice. A diaphragm and spring-operated differential valve keep a constant differential across this orifice. The constant differential pressure across the meter valve orifice results in a constant flow rate for each meter valve setting.

Inlet pressure registers on the meter valve orifice and also beneath the diaphragm by means of external tubing [Fig. 3]. Fluid flowing through the meter valve enters a piezo chamber around the seat ring. An internal passage allows intermediate pressure to enter the diaphragm chamber. In this way, a pressure differential is placed on the diaphragm. The diaphragm is balanced by the spring force, placing the differential valve plug at some intermediate opening. Fluid in the seat ring chamber then can flow through the differential valve into the downstream system.

The controller quickly compensates for varying inlet or downstream pressures. Rising inlet pressure or decreasing downstream pressure causes a momentary increase in the flow rate due to the new differential pressure across meter valve orifice. The differential valve moves toward the closed position to re-establish the same differential pressure across the meter valve orifice as before. Thus, the set flow rate returns to the correct setting. If inlet pressure decreases or downstream pressure rises, there is a momentary decrease in the flow rate. The differential valve opens to compensate for the new pressure conditions and to bring the flow rate back to the desired setting.

A relief valve between the inlet section and the diaphragm chamber prevents abnormal differential pressures on the diaphragm. This condition could occur if the inlet line is opened rapidly with the meter valve closed. Intermediate pressure could not register in the diaphragm chamber to balance the diaphragm, and the relief valve would open to supply the balancing pressure. When this unbalanced condition is restored to a reasonable value, the relief valve automatically closes.

The automatic flow controller may be rough set by a direct scale reading in barrels per day on the travel indicator of the meter pin. For maximum accuracy, the capacity adjustment chart should be used to establish precise meter pin settings as corrected for specific gravity.

The chart provides the exact meter valve setting needed to give the desired flow rate [Fig. 4]. To use it, start on the specific gravity scale of the liquid to be used, and move up the graph to the required flow in barrels per day. Connect this point to the controller capacity line to "Turns Open", which gives the number of turns of the meter valve handwheel required for the current flow rate.

Example 1

Given 1.05 specific gravity and flow of 450 B/D. A point is made on the graph at 1.05 specific gravity and 450 B/D. Connect this point to the capacity curve with a straight line and then draw a straight line down to "Turns Open". A meter valve opening of 1.2 turns open is required. Gal/minute can be used instead of B/D if necessary.

Example 2

Given 1.06 specific gravity and flow of 20 gal/minute. A straight line is drawn from 20 gal/minute to the 1.0 specific gravity scale to obtain a scale reading of 685 B/D. This point is connnected to the same figure [685 B/D] at 1.06 specific gravity by projecting parallel to the equal capacity lines. The same procedure as described in Example 1 is then followed to arrive at a reading of 2.13 turns open.

CONCLUSION

Use of the local control element in designing an automated injection system represents a potential savings in capital investment. The device promotes design simplicity and reduces the need for specialized instrument technicians. Because of the design reliability of the local control element, there should be less need for constant monitoring of injection well performance. The degree of sophistication and quantity of accessory equipment at the injection well may be reduced. The local control element accurately and automatically controls the injection rate.

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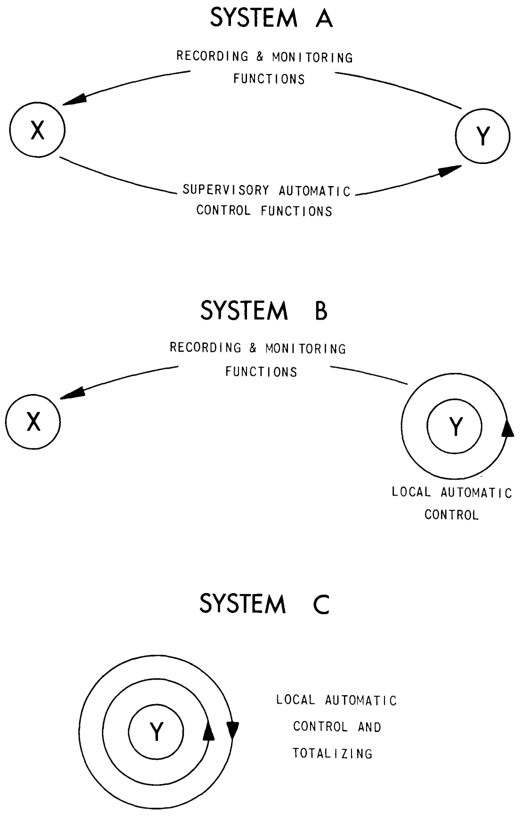

Fig. 1.

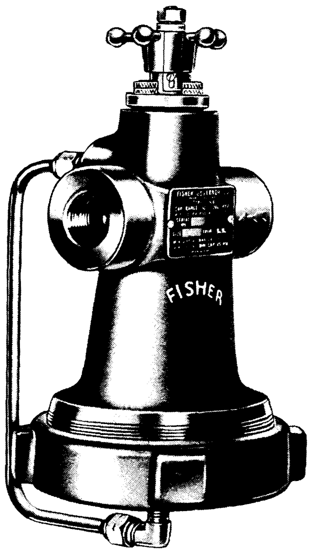

Fig. 2.

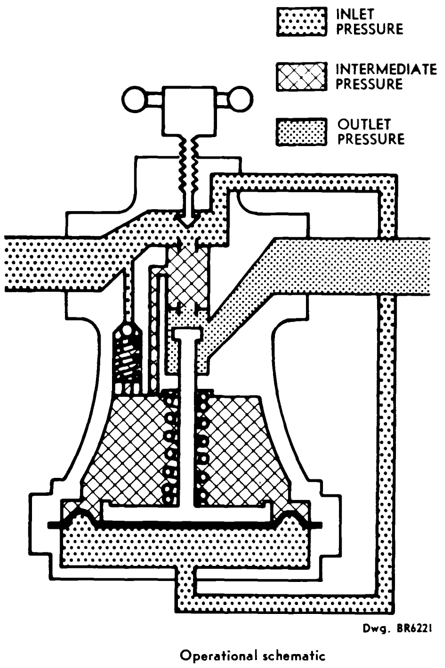

Fig. 3 - Operational schematic.

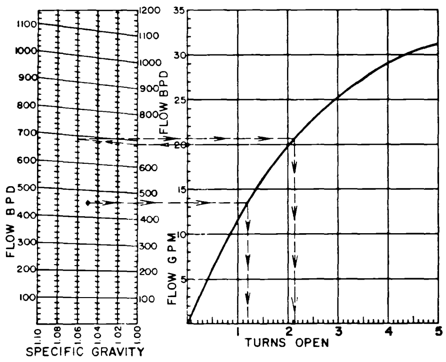

Fig. 4 - Flow vs turns open chart.